PERFORMANCE EVALUATION OF GREEN INHIBITORS IN CHLORIDE INDUCED CORROSION OF REINFORCING STEEL EMBEDDED IN CONCRETE

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Abstract

This study investigates the corrosion inhibition efficiency of some organic inhibitors and compares its performance against inorganic inhibitors. The inorganic inhibitors used in the study were sodium molybdate dihydrate ($Na_2MoO_4 \cdot 2H_2O$), benzotriazole, while organic inhibitors were prepared from Azadirachta indica (AI) and Calotropis gigantea (CG) plant. The concrete specimens were contaminated during concrete preparation with 2% NaCl by weight of cement. To evaluate the effect of these inhibitors on corrosion of reinforcing steel, cylindrical concrete specimens with centrally embedded reinforcement were prepared. Further to accelerate the corrosion process the specimens after curing period were exposed to NaCl(4%) solution. Concrete cube specimens were used to evaluate the effect of inhibitors on the compressive strength of concrete. The results of the study indicated that the corrosion inhibitors investigated in this study did not have adverse effects on compressive strength of concrete. Furthermore, Benzotriazole proved to be effective in delaying corrosion initiation of reinforcing steel embedded in concrete specimens contaminated with NaCl compared to $Na_2MoO_4 \cdot 2H_2O$. Observing the performance of both organic inhibitors, AI inhibitor performed better in mitigating the reinforcing steel corrosion compared to CG.

Keywords: Concrete; Reinforcing Steel, Benzotriazole; Molybdate; Calotropis; Internal chloride; Inhibitors; Corrosion; Azadirachta Indica; Calotropis Gigantea

1. INTRODUCTION

Corrosion has a significant impact on the global construction industry, resulting in significant economic losses and safety implications. Global statistics indicate that corrosion costs approximately 3-4% of the world's gross domestic product (GDP) annually. According to a recent report by The National Association of Corrosion Engineers (NACE) India Chapter, in India, corrosion costs account for 5-7% of GDP, which is more than the defense budget. Failure of infrastructure due to corrosion also affects the country's economy [1]. This enormous cost represents the extensive resources needed to repair and replace corroded structures, equipment, and materials. Corrosion not only affects the economic aspect of the construction industry but also poses serious safety hazards. Structural integrity can be compromised by corrosion, leading to the potential collapse of buildings, bridges, pipelines, and other critical infrastructure. This puts lives at risk and requires costly remedial efforts to ensure public safety [2,3].

It is important to investigate corrosion mitigation methods in the construction industry. By developing effective strategies to prevent or reduce corrosion, the industry can significantly reduce maintenance and repair costs, extend the lifetime of structures, and improve overall operational efficiency. Loss of alkalinity and varying freezing and thawing temperatures are the two main factors that have an impact on the corrosion of reinforcing steel embedded in concrete. Carbon dioxide can enter concrete and cause a decrease of alkalinity in the concrete pore solution [4]. The pozzolanic materials may also consume portlandite and decrease the alkalinity of concrete. Most reinforced concrete buildings in cold climates frequently experience freeze-thaw damage, which makes it easier for chlorides and carbon dioxide to ingress into the concrete and worsens the corrosion of the reinforcing bars. The chloride ions entered the concrete accumulate at the reinforcing steel surface and initiate the corrosion after the chloride concentration reached threshold. It is widely known that while chlorides may not directly destroy concrete, they do target the passive layer that surrounds reinforcing steel and start corrosion [5]. It is widely known that while chlorides may not directly damage concrete, they do target the passive layer that surrounds reinforcing steel and initiate corrosion. Rust on reinforcing steel with corrosion creates expansive stresses on nearby concrete due to the increased volume of steel with rust, which leads to concrete spalling. Rust on reinforcing steel with corrosion creates expansive strains on nearby concrete due to the increased volume of steel with rust, which leads to concrete spalling. When making new concrete, chloride ions can enter the mixture using superplasticizers, contaminated aggregate, contaminated water, and seawater. Unlike corrosion brought on by chloride entering hardened concrete, this internal chloride corrosion mechanism is distinct from that.[6]

Scientific evidence also supports the need to address corrosion in construction. Research studies have demonstrated the detrimental effects of corrosion on various materials and structures, providing valuable insights into the underlying mechanisms and degradation processes [7-9]. For example, studies have shown that corrosion of reinforcing steel in concrete structures can lead to concrete cracking, spalling and reduced load-bearing capacity. Furthermore, advances in corrosion science and technology have led to the development of innovative corrosion mitigation techniques. These include corrosion-resistant materials, protective coatings, mineral admixtures, cathodic protection systems and corrosion inhibitors. By researching and implementing mitigation techniques, the construction industry can reduce the impact of corrosion on infrastructure, reduce maintenance costs, increase structural durability, and improve the overall sustainability of construction projects. This proactive approach to corrosion management is essential to the industry's continued growth, safety and financial sustainability in the coming years.

In order to protect the reinforcing steel embedded in concrete many techniques and methods have been reported in earlier literature they are – altering water to cement ratio, utilization of mineral admixtures, corrosion inhibitors, concrete surface coating, improving the metallurgical properties of reinforcing steel, cathodic protection, coating on reinforcing steel, fibre reinforced concrete, re-alkalization of carbonated concrete, electrochemical chloride extraction, and so on[10-14]. Corrosion inhibitors play a vital role in the protection

of reinforcing steel embedded in concrete. They are highly valued in the concrete industry due to their usefulness, cost-effectiveness, and ease of implementation. By using corrosion inhibitors, the corrosion potential of reinforcing steel is significantly reduced, leading to improved durability and longevity of concrete structures. Corrosion inhibitors can be generally classified as organic and inorganic. On other hand inhibitors can also classified by based on their protection mechanisms, and mode of application. Nitrates, molybdates, phosphates, chromate, silicate, zinc, benzoate, tungstate and so on are some examples of inorganic inhibitors among these nitrate is most popular in construction industry [15-19]. Most of the inorganic corrosion inhibitors, e.g., nitrites and molybdates, had been banned in many countries and regions due to their high biological toxicity and carcinogenicity [20].

Due to the presence of heteroatoms including oxygen, nitrogen, sulphur, phosphorous, conjugated double bonds, and aromatic rings, organic inhibitors can perform both anodic and cathodic actions. These hetero atoms assist in the physical and chemical adsorption process on the steel reinforcing surface, aid in the formation of a stronger bond with the steel-concrete contact, and so block active corrosion sites [21-24].

Numerous green corrosion inhibitors are employed to reduce corrosion in reinforced concrete structures because of their widespread availability, environmental friendliness, biodegradability, low toxicity, and regenerative properties. Biopolymers, surface-active substances, pharmaceuticals, chitosan, honey, yeast, plant extracts, and amino acids are a few of them. When the organic inhibitors are added in mixing water in concrete, organic compounds in inhibitor adsorbed on the metal surface and form passive layer around it. Phytochemicals present in organic inhibitors help to strongly bind on the metal surface.

Aspita et al. [25] examined the effectiveness of Bambusa arundinacea [Indian Bamboo] leaf extract as a corrosion inhabitant when compared to the inorganic inhibitors calcium nitrite and ethanolamine inhibitors. Due to its hydrophobic effect and effective adsorption properties, they reported that Bambusa arundinacea is a better option than nitrite and amine-based corrosion inhibitors. Additionally, it maintains the calcium silicate hydrates (C-S-H) gel, which stops calcium hydroxide from converting to calcite and carbo-aluminate phases. The effectiveness of Bambusa glauscescens [multiplex] extract on mild steel corrosion deterioration in sulphuric acid was studied by Omotosho et al. [26]. They noticed a decrease in corrosion rate as extract concentration increased. Additionally, the microstructural analyses showed that as the extract concentration increased, the dominant coarsening of the iron oxide phase decreased significantly, while the pearlite and ferrite phases became finely dispersed.

Kola plant and tobacco extracts ability to resist the corrosion of reinforcing steel embedded in concrete at different concentrations was studied by Loto et al. [27]. It was observed that adding different amounts of plant extracts decreased the mild steel corrosion subjected to sodium chloride. This behavior was attributed to the protective coating provided on the surface of the steel in the concrete by the complex chemical compounds of the plant extracts. The best results were observed by the tobacco extract. Peter and Sharma [28] studied the ability of AI to suppress corrosion on mild steel when

exposed to HCl, H_2SO_4, and HNO_3 solutions. The findings indicated that increasing the inhibitor concentration enhanced the effectiveness of the inhibition, and it was also observed that the Langmuir adsorption isotherm was followed at all concentrations in the various acidic mediums investigated. Most of the researchers [28-35] studied the efficiency of AI on mild steel and copper metal samples subjected to various acid solutions and they also reported the similar trend. AI was found to be effective in inhibiting microbial corrosion of copper by resisting the growth of the bacteria [36,37].

This study investigates the corrosion inhibition efficiency of two organic inhibitors and two inorganic inhibitors namely sodium molybdate dihydrate ($Na_2MoO_4 \cdot 2H_2O$), benzotriazole. Leaf extracts of Azadirachta indica (AI) and Calotropis gigantea (CG) are used as organic inhibitors. Corrosion potentials and corrosion current density measurements were used to assess the effectiveness of the selected inhibitors in decreasing reinforcement corrosion.

2. EXPERIMENTAL PROGRAM

2.1. Materials

In this investigation, cylindrical specimens of diameter 75 mm and height 150 mm were prepared with centrally embedded reinforcing steel, concrete cube specimens of size 150 mm x 150 mm were prepared. A 12 mm diameter steel bar was employed and an effective cover of 44 to 45 mm at the bottom was maintained for concrete specimens with centrally embedded reinforcing steel. OPC 53 grade cement confirmed IS 12269 [32] that is readily available on the market was utilized. The specific gravity of fine and coarse aggregate is 2.66 and 2.68 respectively concrete mixtures were prepared for effective water to cement ratio of 0.5. The coarse aggregate with maximum size of 20 mm and 10mm were used in the proportion of 60 and 40 respectively in all concrete mixtures. The water absorption of coarse and fine aggregate are 2.8% and 0.57% respectively.

The corrosion inhibition properties of AI and CG in chloride–containing simulated concrete pore solution (SCPS) were investigated by aqueous extraction of AI and CG leaves. The corrosion inhibition properties were tested by Linear Polariztion Resistance method. The experimental results suggested that AI and CG have the combined properties of eco–friendly and long–term efficient corrosion resistance.

Two types of organic inhibitors, which are leaf extracts of Azadirachta Indica (AI) and Calotropis Gigantea (CG) are used. The performance of organic inhibitors was compared with two inorganic inhibitors namely sodium molybdate dihydrate ($Na_2MoO_4 \cdot 2H_2O$), benzotriazole. Analytical reagent sodium molybdate dihydrate and benzotriazole with purity of 99.0% of various dosages of 0, 1, 2 and 3% of cement were added.
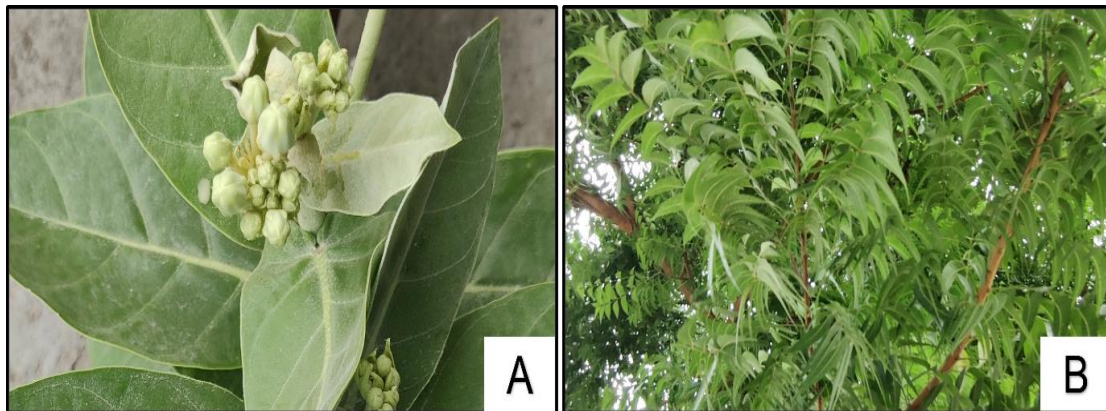
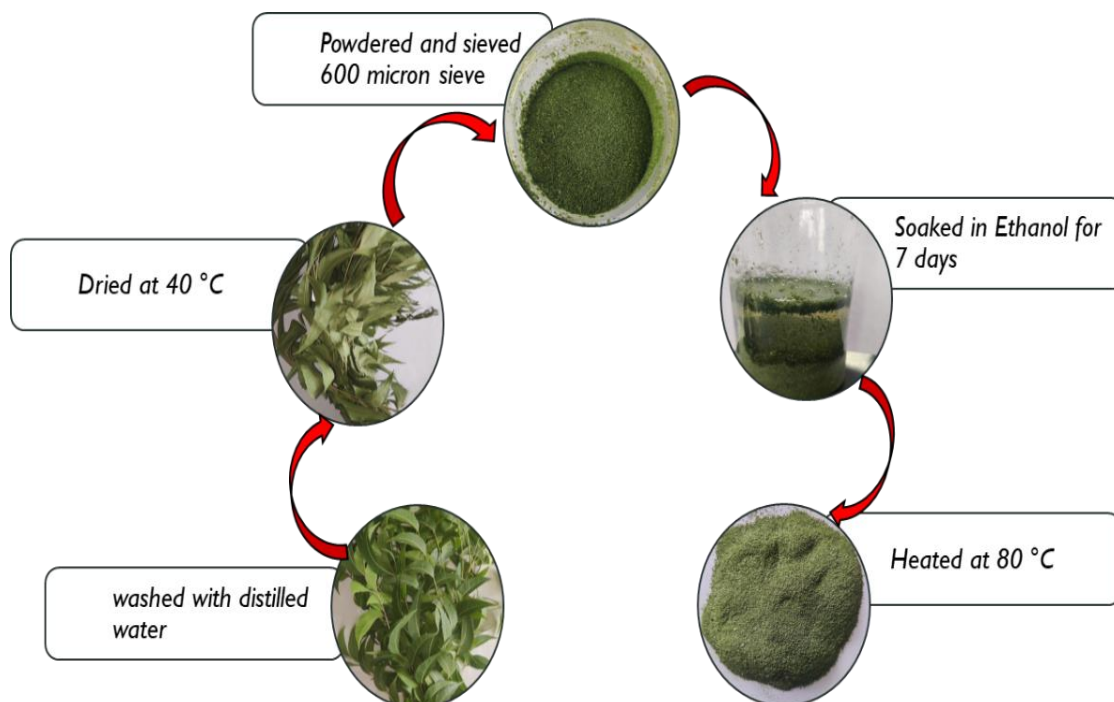**Figure 1: A) Calotropis Gigantea and B) Azadirachta Indica**

Figure 2: Schematic diagram of synthesis of AI inhibitor

The reinforced concrete specimens were contaminated with 2% of sodium chloride (NaCl) solution. After casting, the samples were covered with wet burlap for 24 hours. The specimens were then demolded and aged in wet burlap for the next 27 days. Three times a day, water was applied to the burlaps. After 27 days of cure, the specimens were exposed to chloride solution. The 2 % NaCl-contaminated samples were partially submerged in 4% NaCl solutions (by volume of water) until the test day. It offers three benefits. By allowing the moisture required for corrosion, it first eliminates the scattering of corrosion data brought on by the concrete dry circumstances. It also helps prevent the

leaching of chloride ions from the contaminated concrete. The worst-case situation can also involve chlorides being present both inside and outside of the concrete. On reinforced concrete cylindrical specimens, the half-cell potential and linear polarization tests for corrosion have been performed on a regular basis. The corrosion monitoring of reinforcing steel bar embedded in contaminated cylindrical concrete specimens with and without four different types of inhibitors was performed using Potentiostat KLyte 1.2.

3. RESULTS AND DISCUSSIONS

3.1 Compressive strength

Concrete cube specimens with different types, different dosages of corrosion inhibitors and with/without chloride contamination were tested for compressive strength at the ages of 7, 28 and 56 days. The results were compared with those made of without inhibitors to evaluate the effect of inhibitor type, age of the concrete, dosage level of inhibitor on compressive strength of concrete. The influence of both organic and inorganic inhibitors on compressive strength of concrete has been shown in Figure 3. The specimen without corrosion inhibitor and contamination was recorded as 26 MPa at 28 days of age. Figure 3 shows that the specimens using the corrosion inhibitors had greater compressive strength than the control specimens. With an inhibitor dosage of 1 % to 3 %, the increase in concrete strength caused by sodium molybdate dihydrate inhibitor varies from 4.6 % to 12.3 %. With benzotriazole, an AI inhibitor, concrete strength values increased from 6 to 13 and 5 to 14 %, respectively, with dosage ranges of 1 to 3%. Although the concrete strength improved by 4.5% with a 1% dosage of CG inhibitor and by 3% with a 2% dosage, the concrete strength reduced by less than 1% at a 3% dosage of CG inhibitor. Concrete specimens polluted with chlorides showed a similar tendency, but the increase was less than for concrete samples made without chloride contamination. It has been found that CG inhibitor had no discernible effects on the strength of chloride-contaminated concrete, even when the CG dosage was increased. Overall, it was found that in the case of specimens without contamination both organic and inorganic inhibitors almost increased the compressive strength by 5 to 12% as the dosage level went from 1 to 3%. The only exception was the 3% dose of CG, which made the strength go down by a small amount, which is not significant either. Compared to specimens made without contamination, there is not a substantial rise in strength with dosage increase in the case of specimens with chloride contamination, and it is almost insignificant in the case of CG.

As previously stated, concrete specimens with and without chlorides were evaluated to understand the impact of inhibitor on chloride-contaminated concrete. Figure 4 shows the compressive strength values for contaminated concrete specimens with and without the sodium molybdate dihydrate inhibitor. Comparing the control specimen with and without chloride contamination, the chloride contaminated control specimen strength decreased from 26 MPa to 23.5 MPa at 28 days of age. According to Figure 4, the strength values of concrete without contamination range from 18 to 31 MPa from 7 to 90 days, while those of specimens with contamination range from 16 to 29 MPa for the same age. Consequently, both with and without inhibitors present, chloride contamination reduces

compressive strength. Compressive strength was significantly influenced by age; it rose significantly up to 28 days, after which the rate of rise decreased.

In summary of the compressive strength results, it was observed that the compressive strength of concrete was not adversely affected by the organic or inorganic inhibitors considered in this investigation
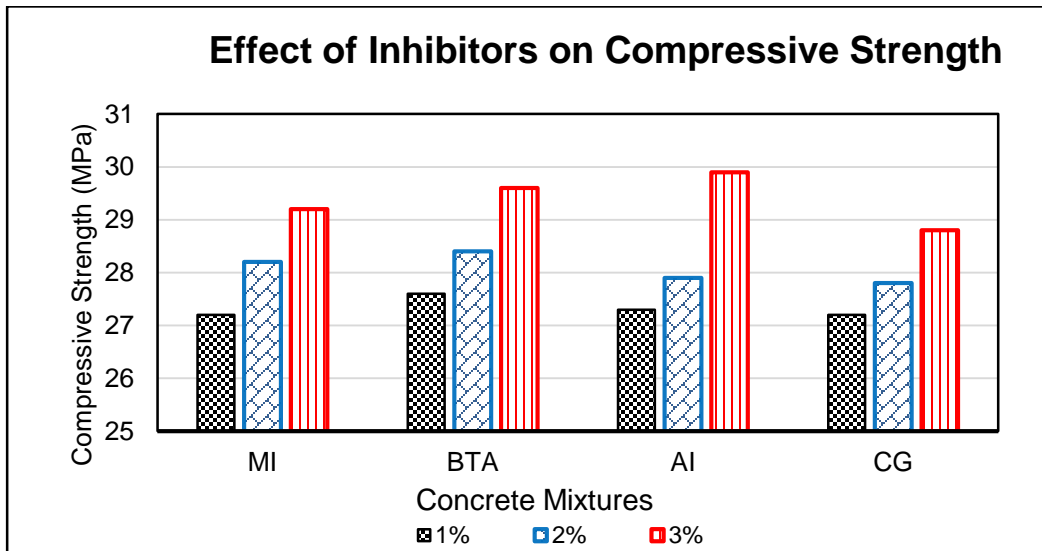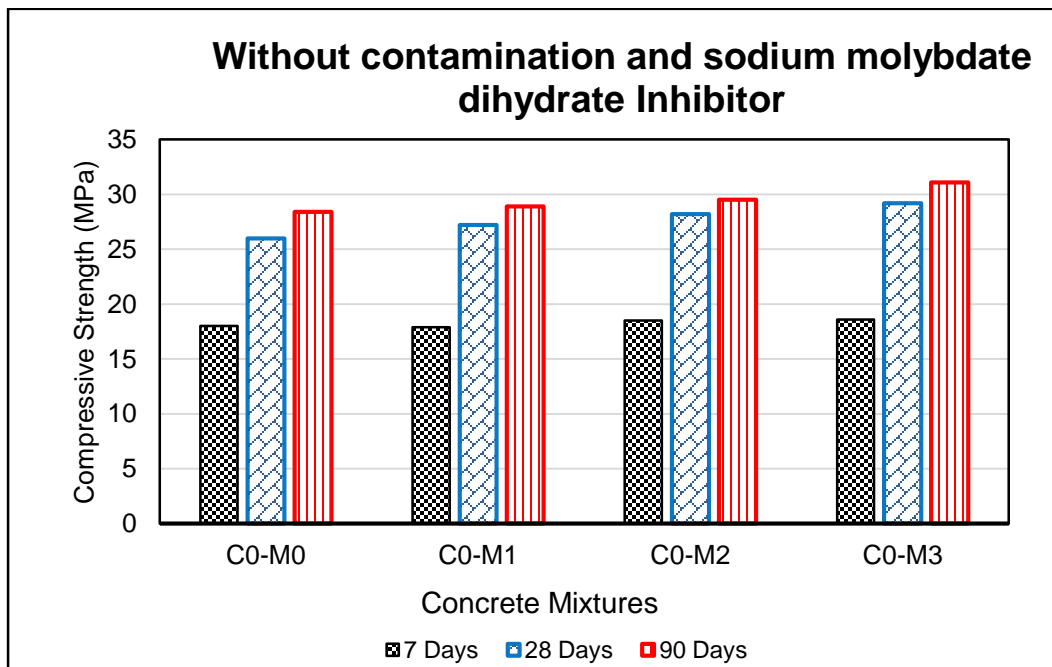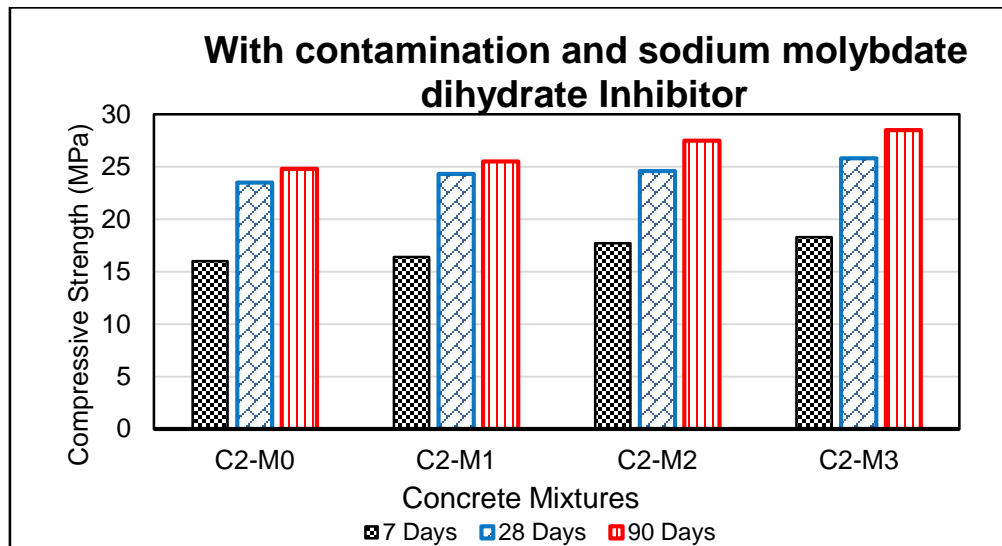

Figure 3: Effect of inhibitor on compressive strength (28 days) of concrete at different dosage

Figure 4: Effect of chloride contamination on compressive strength of concrete specimens incorporated sodium molybdate dihydrate inhibitor at different ages.
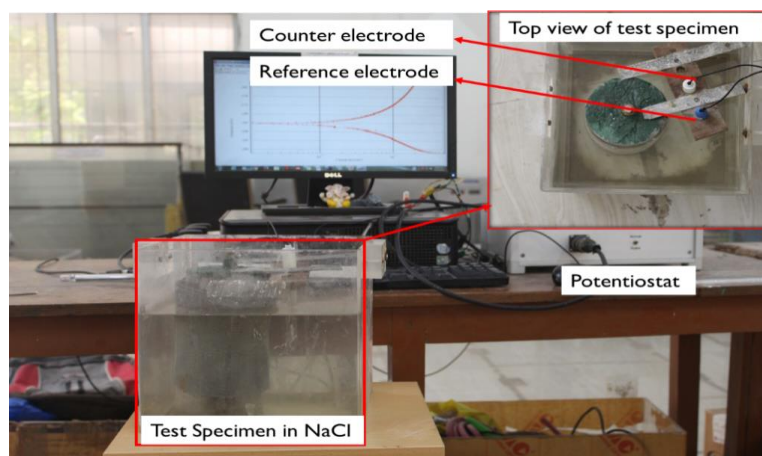
3.2 Corrosion measurement

3.2.1 Contaminated concrete admixed with inorganic inhibitor

Corrosion potentials and corrosion current density values are monitored over a period of 420 days to assess the corrosion resistance performance of inorganic inhibitors namely sodium Molybdate dihydrate, benzotriazole on rebar embedded in contaminated concrete mixtures.

The corrosion potential values have been measured on cylindrical specimens using standard calomel electrode (SCE) as the reference electrode, rebar in concrete as working electrode as shown in Fig 5. The measured potential values were interpreted with reference to ASTM C876 to qualitatively analyse the status of corrosion on rebar. The potential values greater than -270 mV (ASTM Threshold value) indicates 90% probability of reinforcing steel corrosion as per ASTM C876 recommendations. Similarly for potential values falling in the range of -270 mV and -120 mV represents uncertainty of corrosion, and the values less negative than -125 Mv represents the probability of 5% of corrosion. Figure 6 shows the corrosion potentials monitored on the specimens having inorganic inhibitors, and Figure 6 shows the values for the corresponding corrosion current densities. The potential values are higher than the ASTM threshold value at the beginning ages, indicating that corrosion may have started early on. It is because chloride, which prevents the development of a passive layer, is present in fresh concrete. The formation of a passive protective layer over the rebar is usually attributed to the high alkalinity of concrete brought on by freed portlandite. The potential values are higher than the ASTM threshold value at the beginning ages, indicating that corrosion may have started early on. This is due to the presence of chlorides in fresh concrete, which prevents the formation of a passive layer. The high alkalinity of concrete caused by portlandite is

typically attributed to the formation of a passive protective layer over the reinforcing bars. In this instance, however, the chlorides in fresh concrete impair the stability and the formation of a passive layer, so promoting corrosion initiation. From Figure 6 and Figure 7, It can be seen that the corrosion potential values of the contaminated specimen without inhibitor (C2-I0) were much more negative than those of the specimens that had inorganic inhibitors at various dosages. This same trend can also be observed in the plot of corrosion current density values shown in Figure 7. Observing the influence of dosage on corrosion inhibition, both inorganic inhibitors namely sodium molybdate dihydrate and benzotriazole have shown better performance with increasing dosage from 1% to 3%. The specimens admixed with 1% of sodium molybdate dihydrate (C2-M1) showed the potentials in the range from -350 to -450 mV, while at the same inhibitor at 3% dosage (C2-M3) the potential values range from -300 to -340 mV as shown in Figure 8. It means that the potential values are moving towards less negative by increasing the dosage from 1% to 3%. Both inorganic inhibitors, sodium molybdate dihydrate and benzotriazole, have shown improved corrosion inhibition with increasing dose from 1% to 3%. The specimens admixed with 1% sodium molybdate dihydrate (C2-M1) displayed potentials in the range of -350 to -450 mV, while the same inhibitor at a dosage of 3% (C2-M3) produced potential values in the range of -300 to -340 mV, as shown in Figure 7. The potential values are trending toward less negative as the dosage is increased from 1% to 3 % and thus improving the corrosion inhibition. Similarly potential values of samples with 1% benzotriazole inhibitor (C2-B1) showed potentials ranging from -460 to -510 mV and samples with same inhibitor with 3% dose (C2-B3) were close to ASTM threshold value for the test period. Using the linear polarisation technique, corrosion current density values are also obtained at regular intervals of 28 days for a period of 420 days to ensure the quantitative corrosion inhibition of inorganic inhibitors. Generally, corrosion current density values are also be interpreted as below 0.1 $\mu A/cm^2$ are considered as low corrosion rate, in the range of 0.1-0.5 $\mu A/cm^2$ as weak corrosion rate, in the range of 0.5-1 $\mu A/cm^2$ as moderate corrosion rate and above 1 $\mu A/cm^2$ as high corrosion rate.

Figure 5: Setup for monitoring the corrosion measurements on cylindrical test specimen
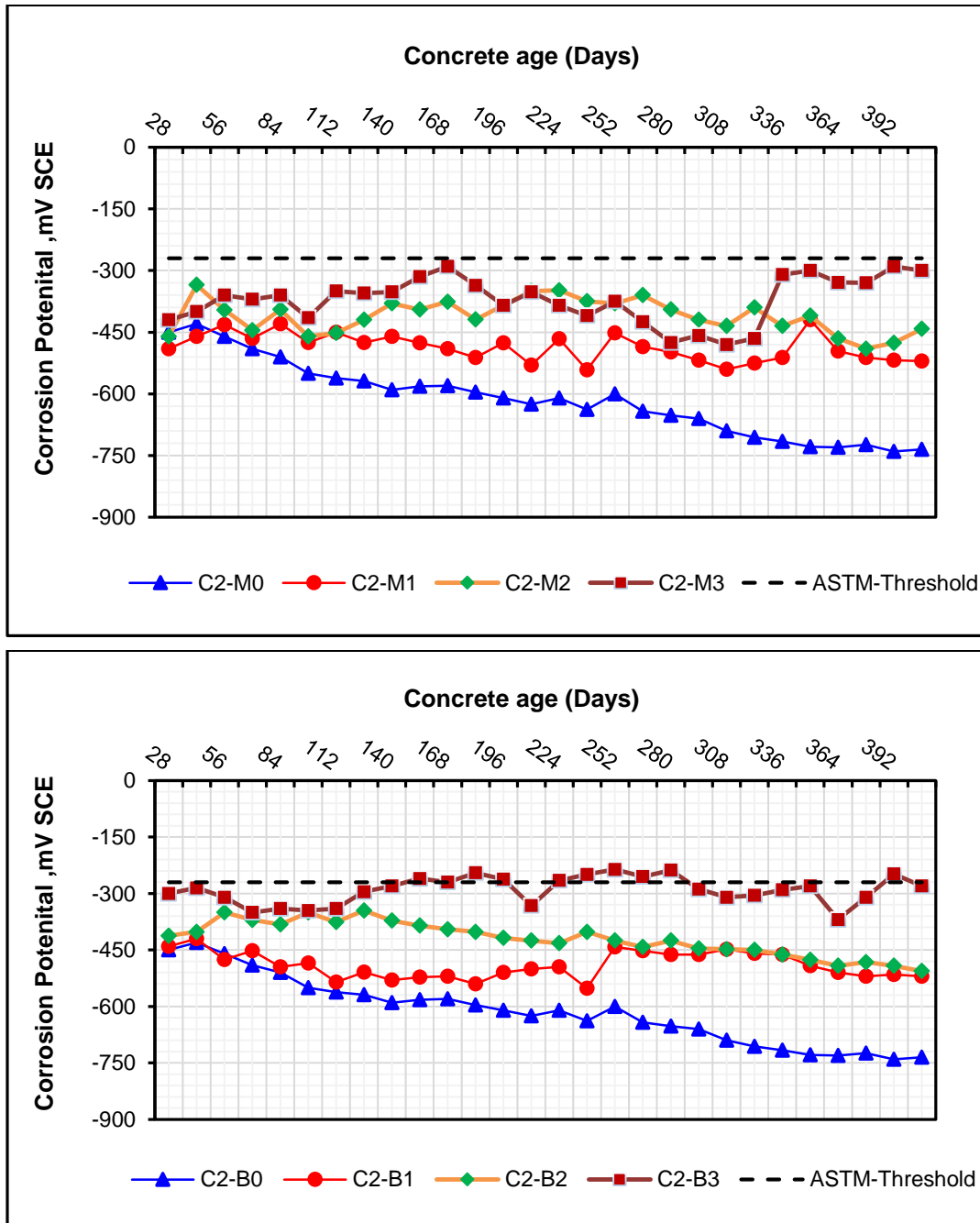
Figure 6: Corrosion potentials of rebar embedded in NaCl contaminated concrete specimens and admixed with A) sodium Molybdate dihydrate B) benzotriazole.

Figure 7 shows that corrosion current density measurements at the beginning of the test ranged from 0.5 to 1 $\mu A/cm^2$, indicating a state of moderate corrosion activity. The specimen without corrosion inhibitor (C2-I0) reached a state of high corrosion activity at an age of less than 140 days. Then the 1% sodium molybdate dihydrate samples reached

a state of high corrosion activity at 170 days. Similarly, the sample containing 2% and 3% sodium molybdate dihydrate (C2-M2 and C2-M2) crossed the 1 µA/cm^2 line at 265 and 330 days of age respectively. The order of samples reaching the state of high corrosion activity was observed as C2-M3 > C2-M2 > C2-M1 > C2-M0. The trends of corrosion current density values of the samples are also changing to higher values with time in the same order. Figure 6 and Figure 7 demonstrating that the sodium molbydate dihydrate is inhibited the chloride induced corrosion compared to those contaminated specimens without any inhibitor and corrosion activity is decreased with increasing the dosage of the inhibitor. While observing the performance of benzotriazole on corrosion inhibition of rebar embedded in chloride contaminated concrete, the specimens admixed with 1% of benzotriazole reached the high corrosion activity state at around 280 days of age, which is almost double to the age at which specimens without inhibitor(C2-I0) have reached. Similarly, the samples treated with 2% and 3% benzotriazole inhibitor reached a state of high corrosion activity at about 365 days of age. By looking at Figure 7 it can be observed that the corrosion behavior of rebar in concrete with benzotriazole followed the order: C2-B3 < C2-B2 < C2-B1 < C2-B0. From the corrosion measurement graphs of inorganic inhibitors, it can be seen that benzotriazole inhibits corrosion and its efficiency also increases with increasing dosage.

In the comparison of the corrosion inhibition efficiency of sodium molybdate dihydrate and benzotriazole inhibitors, the following observations were made:

As far as Corrosion Potential Values are concerned samples admixed with benzotriazole exhibited lower negative potential values compared to those admixed with sodium molybdate dihydrate at the same dose level. This suggests that benzotriazole is more effective in preventing passive layer damage due to chlorides and thus shifting the corrosion potential of rebar to a less corrosion probability.

Samples with benzotriazole showed lower corrosion current density values compared to those specimens with sodium molybdate dihydrate at the same dose. A lower corrosion current density indicates a reduced rate of corrosion, indicating that benzotriazole provided better corrosion protection.

Specimens treated with benzotriazole remained in the moderate corrosion activity state for a longer period, but samples treated with sodium molybdate dihydrate could not remain in the moderate corrosion state for long and shifted to the high corrosion state earlier than the benzotriazole treated specimens. This indicates that the benzotriazole provided sustained protection and delayed corrosion progression.
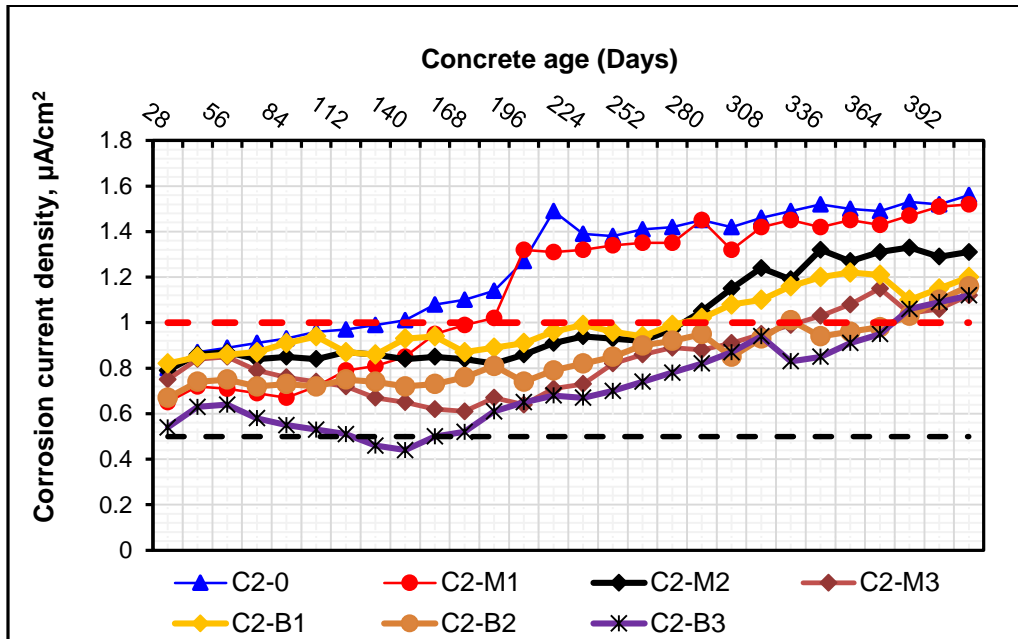
Figure 7: Corrosion current density values of rebar embedded in NaCl contaminated concrete specimens and admixed with sodium Molybdate dihydrate benzotriazole.
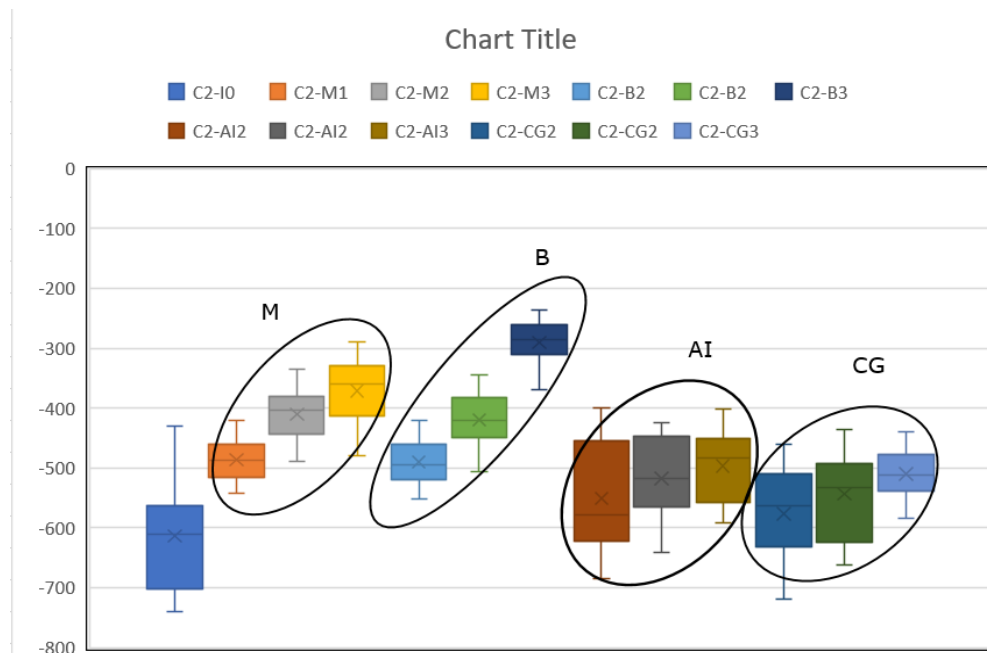

Figure 8: Range of corrosion potentials of reinforcing steel bar in concrete incorporated with different corrosion inhibitors
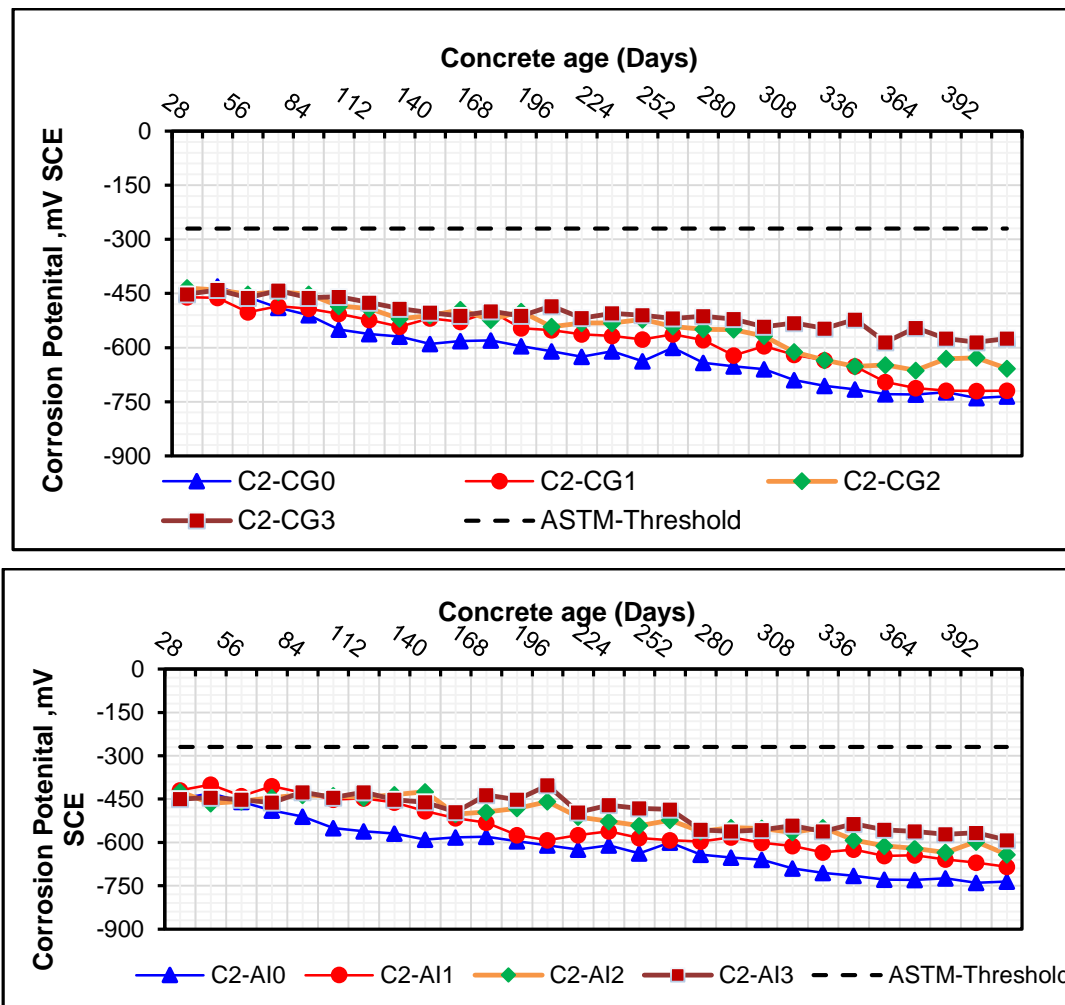
3.2.2 Contaminated Concrete Admixed with Organic Inhibitor

Another set of experiment was conducted on contaminated concrete specimens having organic inhibitors and the change of potential of rebar was measured and results are shown in Figure 9. Figure 9 shows that the corrosion potential values of samples mixed with AI and CG were negative than -270 mV, and this indicated corrosion initiation on the rebar in the concrete at the beginning of the test. It can be attributed to the chloride ions present during concrete mixing which does not the formation of passive layer. The corrosion potential values of contaminated specimens admixed with AI (C2-AI1, C2-AI2, and C2-AI3) and CG extract (C2-CG1, C2-CG2, and C2-CG3) were less negative compared to those contaminated specimens prepared without inhibitor (C2-I0). This indicates that AI and CG extracts prevent the damage caused by the effect of chloride ions on the passive layer and thus shift the potential values to a lower corrosion potential state. The specimens admixed with 1% of CG (C2-CG1) showed the potentials in the range from -510 to -630 mV, while at the same inhibitor at 3% dosage (C2-CG3) the potential values range from -480 to -540 mV as shown in Figure 8. Similarly potential values of samples with 1% AI (C2-AI1) showed potentials ranging from -450 to -630 mV and samples with same inhibitor with 3% dose (C12-AI3) were -450 to -550 mV. That is, increasing the dosage of AI and CG leaf extract from 1% to 3% increased the anti-corrosion performance similar to the previous experiment using organic inhibitors. However, the comparison of the potential ranges of CG and AI as in Figure 8 showed a higher shift of potential in the positive direction in the case of AI as compared to CG. This suggests that AI is relatively more effective than CG inhibitor in terms of half-cell potential measurement. Samples containing organic inhibitor CG with doses of 1, 2 and 3% changed from moderate corrosion state to high corrosion activity state at 180, 190 and 210 days, respectively. But the specimen without corrosion inhibitor (C2-I0) reached a state of high corrosion activity at an age of less than 140 days. Examining the samples with AI, samples with 1, 2 and 3% AI admixed doses reached the state of high corrosion activity at 190, 224 and 230 days, respectively. This indicates that with increasing the dosage of AI the corrosion inhibition capacity also increases similar to the results observed in the case of CG inhibitor at the same contamination.

At the same dose, samples mixed with AI had lower negative potential values and low corrosion current density values than those mixed with CG. This suggests that AI is more effective in resisting the corrosion initiation and rate of corrosion of rebar in contaminated concrete. It suggests that specimens treated with AI remained in the moderate corrosion activity state for a longer period compared to those admixed with CG. From this study, it is clear that the both organic and inorganic inhibitors considered in this study are inhibited the corrosion of rebar in chloride contaminated concrete. Comparatively the inorganic inhibitors performed well in corrosion inhibition with low corrosion potential values, corrosion current density values than the organic inhibitor. The main objective of this study is to investigate the corrosion inhibition potential of CG and AI and evaluate the performance with the comparison of organic inhibitors. In this regard, it can be observed that the samples mixed with CG remained in moderate corrosion state for 40–60 days

and the samples mixed with AI reached high corrosion state only after 50–90 days. In the case of inorganic inhibitors, samples with sodium molybdate dihydrate remained in moderate corrosion condition for up to 190 days and the same samples with benzotriazole for up to 225 days. Although the efficiency of organic inhibitors in inhibiting chloride induced corrosion is much lower than that of inorganic inhibitors, it should be noted that AI and CG inhibitors are sustainable and environmentally friendly inhibitors. As this work was limited to a 3% dose, research with further doses of organic inhibitors could assess its best inhibitory potential. Researchers found that green inhibitors demonstrated to be ideal for the replacement of the traditional expensive, toxic, and synthetic organic corrosion inhibitors. The green inhibitors contain several constituents that can absorb and inhibit metallic corrosion [35].

Figure 9: Corrosion potentials of rebar embedded in NaCl contaminated concrete specimens and admixed with A) Calotropis Gigantea and B) Azadirachta Indica
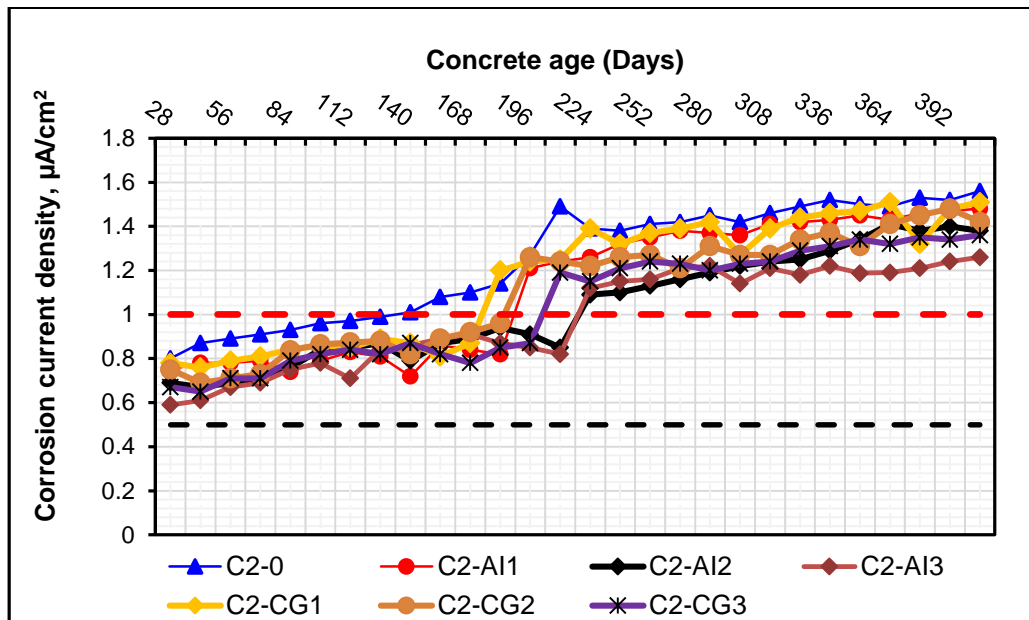
Figure 10: Corrosion current density values of rebar embedded in NaCl contaminated concrete specimens and admixed with Calotropis Gigantea and Azadirachta Indica.

4. CONCLUSION

The study investigated the performance of organic inhibitors in chloride induced corrosion and compares it against performance of inorganic inhibitors on the compressive strength of concrete and their potential in resisting the corrosion of rebar in chloride-contaminated concrete. Inorganic inhibitors, namely sodium molybdate dihydrate and benzotriazole and organic inhibitors, CG and AI, were tested.

The findings demonstrated that the inhibitor-added concrete samples had no significant impact on compressive strength. With a dosage of 1% to 3% of sodium molybdate dihydrate and benzotriazole, the increase in concrete strength ranged from 4.6 to 12.3 percent and from 5 to 14 percent, respectively. Overall, nevertheless, the inhibitors had no negative effects on the concrete compressive strength.

Regarding corrosion inhibition, inorganic inhibitors namely sodium molybdate dihydrate, benzotriazole and green inhibitors namely AI and CG showed promising results. Corrosion potential and current density results showed that inorganic inhibitors performed better than organic inhibitors. The organic inhibitors, CG and AI, showed considerable protection against corrosion but were less efficient compared to inorganic inhibitors.

Overall, the study showed that corrosion inhibitors, especially inorganic ones, can offer rebar corrosion protection in situations with chloride contamination. Despite being less effective, organic inhibitors showed promise as non-toxic, ecologically friendly alternatives.

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